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Do floods of brief duration affect the aquatic macroinvertebrate community in a floodplain oxbow lake in the South of Brazil?

Raquel Reis Teixeira[1]

Leonardo Maltchik[1]
maltchik@unisinos.br

Cristina Stenert[1]

Abstract

The effects of floods of brief and very brief duration on the number of taxons, density and composition of macroinvertebrates were recorded in a floodplain oxbow lake in the South of Brazil over a year. Twelve collections were distributed in two hydrological phases (with floods and without floods). The oxbow lake experienced three flood events. A total of 1,225 macroinvertebrates representing 50 taxons was sampled. The majority of the macroinvertebrate taxons corresponded to aquatic insects (67.3%). Tubificidae, Glossiphoniidae and Ephydridae represented the dominant macroinvertebrate families. The number of taxons and density of macroinvertebrates did not change after the flood events of brief and very brief duration and the recurrence of the floods did not diminished the resistance of the dominant macroinvertebrate families. The macroinvertebrate composition varied along the hydrological phases. The first and the second axes of DCA explained 48.2% of the variance in the macroinvertebrate composition. Sphaeriidae, Tubificidae and Glossiphoniidae families were more associated to the phase with floods and Hydracarina, Curculionidae and Dytiscidae taxons were more associated to the phase without floods.

Key words: macroinvertebrates, floods, duration, frequency, resistance.

Resumo

Os efeitos das inundações de breve e muito breve duração no número de táxons, densidade e composição de macroinvertebrados, foram analisados em um meandro antigo de arroio associado a uma planície de inundação no Sul do Brasil ao longo de um ano. Foram realizadas doze coletas distribuídas em duas fases hidrológicas: com inundações e sem inundações. Três inundações ocorreram no meandro antigo de arroio. Um total de 1.225 macroinvertebrados representando 50 táxons foi coletado. A maioria dos táxons era de insetos aquáticos (67,3%). Tubificidae, Glossiphoniidae e Ephydridae foram as famílias dominantes. O número de táxons e a densidade de macroinvertebrados não variaram após as inundações de breve e muito breve duração, e a recorrência das inundações não diminuiu a resistência das famílias dominantes de macroinvertebrados. A composição de macroinvertebrados variou ao longo das fases hidrológicas. O primeiro e o segundo eixos da "DCA" explicaram 48,2% da variação na composição de macroinvertebrados. Sphaeriidae, Tubificidae e Glossiphoniidae foram mais abundantes na fase com inundações, e Hydracarina, Curculionidae e Dytiscidae foram mais abundantes na fase sem inundações.

Palavras-chave: macroinvertebrados, inundações, duração, freqüência, resistência.

[1] Laboratório de Ecologia e Conservação de Ecossistemas Aquáticos – UNISINOS. Av. Unisinos, 950, CEP 93022-000, São Leopoldo, RS, Brasil.

The ecological importance of the floods is far greater than a simple exchange of organic matter between the main channel and the floodplain system (Benke *et al.*, 1999). Floods provide a temporary habitat for fishes and other aquatic organisms several times larger than the area of the river channel (Ross and Baker, 1983). The flood-pulse concept (FPC, Junk *et al.*, 1989) identifies the floods as the principal agent controlling the adaptations of most of the biota in river-floodplain systems. The different attributes of floods such as, for example, frequency, duration and predictability can influence the life stories of aquatic organisms (Fritz and Dodds, 2004; Tronstad *et al.*, 2005; Benke, 2001).

Boulton and Jenkins (1998) argued that most aspects of the water regime of floodplains, such as duration, frequency and amplitude of floods can affect the macroinvertebrate community in floodplain systems. Floods of long duration may increase the macroinvertebrate richness in temporary wetlands (Boulton and Suter, 1986; Davies, 1996), facilitating the input of macroinvertebrates from the river channel to floodplain wetlands (Stenert *et al.*, 2003). Williams (1997) noticed that the water movement between floodplain systems and the river channel during the flooding period allow for the exchange of macroinvertebrates between both systems.

Most of the studies that analyzed the effects of flood events on macroinvertebrate community were carried out in arid floodplain wetlands (Boulton and Lloyd, 1991; Boulton, 1992; Boulton and Jenkins, 1998; Timms and Boulton, 2001) and they analyzed the effects of events of long duration (Stenert *et al.*, 2003; Santos *et al.*, 2003). Studies that analyze the flood effects of brief duration (less than three days) on macroinvertebrate community are largely unstudied in floodplain systems.

The objective of this study was to analyze the effects of floods of brief and very brief duration (up to 3 days) on the number of taxons, density and composition of macroinvertebrates in a floodplain oxbow lake in the South of Brazil over a year.

The study was carried out in a floodplain oxbow lake associated to the Guari stream located in the South of Brazil (Novo Hamburgo, Rio Grande do Sul) (29°43'19.7''S, 51°01'26.0''W). The floodplain has approximately 1,800 ha and is associated with the Guari stream, a third order permanent tributary of the lower course of the Sinos River. It is 11 km long, from its origin 100 m above sea level, to its confluence with the Lomba Grande wetland, 3 m above sea level. Annual precipitation in the Sinos River basin (~4,000 km^2) ranges from 1,200 to 2,000 mm/y and is distributed throughout the year. Increases in discharge due to high precipitation generate a series of floods that temporarily inundate the floodplains.

The oxbow lake is connected to the Guari stream only during the flood period. The oxbow lake is 400 m long and 5 m wide, with maximum depth of 70 cm during the periods without inundation. The hydric soil is constituted basically by silt. Stands of *Eichhornia crassipes* and *Eichhornia azurea* were distributed along the oxbow lake.

Twelve monthly macroinvertebrate collections were carried out from April 2003 to March 2004. In each collection five macroinvertebrates samples were collected at random along the whole area of the floodplain oxbow lake (~2,000 m^2). The samples were collected using a corer (7.5 cm diameter) inserted 5 cm into the substratum, preserved in 10% formaldehyde and taken to the laboratory, where they were elutriated through 0.42 mm mesh to remove mud and vegetal remains. The used mesh size was small enough to retain most macroinvertebrates (Resh and McElravy, 1993; Batzer *et al.*, 2001; Rosenberg *et al.*, 1997).

For the sorting and classification of the macroinvertebrates specimens in the laboratory it was used a 40X magnification through a stereomicroscope, and then the organisms were kept in small tubes with 80% alcohol in the reference collection of the Laboratório de Ecologia e Conservação de Ecossistemas Aquáticos (UNISINOS). The macroinvertebrate classification was made based on Merritt and Cummins (1996), Lopretto and Tell (1995), Fernández and Domínguez (2001) and Borror and Delong (1969).

The flood duration was measured in days and classified as brief (between two and seven days) and very brief (between 4 and 48 hours) (Tiner, 1999). The number of taxons and density of macroinvertebrates was the total number of families and individuals per collection (n=5), respectively. The variations of the number of taxons and density of macroinvertebrates over the studied period and between the hydrological phases (with and without floods) were quantified through analysis of variance (One-Way ANOVA) and *t*-test, respectively. The macroinvertebrate density was log transformed to remove the heteroscedasticity.

A paired *t*-test was used to determine whether the significant differences in the number of taxons and density of macroinvertebrates existed between dates immediately prior to and after floods. The density variation of the more representative families was compared before and after each flood through a *t*-test. If these differences were not significant ($p>0.1$), the macroinvertebrate community was considered resistant to floods (Grimm and Fisher, 1989). The composition of macroinvertebrates along the studied period was analyzed through Detrended Correspondence Analysis (DCA). Then, collection scores categorized according to the hydrological phase were compared through *t*-test.

The oxbow lake experienced three flood events. Two floods were considered of very brief duration (one day) and one flood was considered of brief duration (three days). The flood events were concentrated on the first half of the studied period: phase with floods (five collections from April 16 to July 9). The remaining period was characterized as phase without floods (seven collections from August 6 to March 12) (Table 1). A total of 1,225 macroinvertebrates representing 50 taxons was sampled. The majority of the macroinvertebrate taxons corresponded to aquatic insects (67.3%). Tubificidae (29.1%), Glossiphoniidae (20.5%) and Ephydridae (14.2%) represented more than 60% of the total number of sampled individuals over the studied period (Figure 1). A total of 34 macroinvertebrate taxons and 564 individuals were recorded in the phase with floods, and 41 taxons and 661 individuals were observed in the phase without flood. While nine macroinvertebrate taxons were present only in the phase with floods, 16 taxons were present only in the phase without floods. The phases with

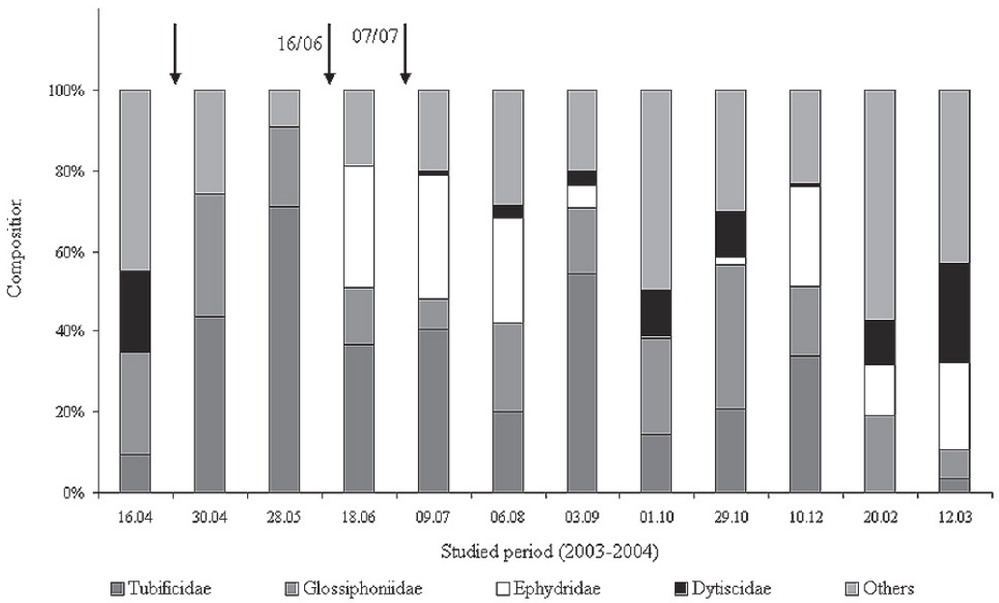

Figure 1. Macroinvertebrate composition over the studied period in an oxbow lake in the South of Brazil. Arrow = flood occurrence.

Table 1. Flood occurrence and duration and macroinvertebrate richness and density (n=5) in the studied oxbow lake over the studied period (2003-2004).

	16/ apr	25/ apr*	30/ apr	28/ may	16/ jun*	18/ jun	7/ jul*	9/jul	6/aug	3/sep	01/ oct	29/ oct	10/ dec	20/ feb	12/ mar
Hydrological phases	Phase with floods								Phase without floods						
Flood duration (Days)	-	1	-	-	1	-	3	-	-	-	-	-	-	-	-
Days after floods (Days)	-	0	5	33	0	2	0	2	30	58	86	114	156	228	249
Total Richness	18	-	16	7	-	16	-	12	19	11	19	13	12	22	12
Mean Richness (± S.E)	7.40 (0.93)	-	6 (0.84)	3 (0.63)	-	5.20 (1.20)	-	5.60 (0.40)	7.80 (1.24)	4 (0.63)	8.80 (1.02)	4.80 (0.97)	5.80 (1.02)	7 (1.41)	3.40 (1.25)
Mean Density (± S.E)	25.40 (5.54)	-	24.80 (7.35)	15.20 (6.03)	-	24.60 (8.18)	-	22.80 (3.84)	35.80 (9.63)	11.40 (5.70)	26.20 (7.06)	10.60 (2.48)	28.40 (8.56)	14.80 (4.02)	5.80 (1.69)

* Flood occurrence
S.E. = Standard Error are in brackets.

floods and without floods showed 25 macroinvertebrate taxons in common. The number of taxons and density of macroinvertebrates did not change after the flood events (Table 2). The recurrence of the floods of brief and very brief duration did not diminish the resistance of the macroinvertebrate community (Table 2). However, the density of Tubificidae increased after the first flood and Dytiscidae disappeared after this event, and was found again only in the end of the flood phase (Table 3, Figure 1).

The number of taxons and density of macroinvertebrates varied during the study period ($F_{11,48}$ = 3.181; P= 0.003 and $F_{11,48}$ = 2.053, P<0.043, respectively), and they were similar between the phases with floods and without floods (t= -0.631, df= 10, P= 0.542 and t= 1.075, df= 10, P= 0.308, respectively) (Table 1).

Based on the DCA ordination, the first and the second axes of DCA explained 48.2% of the variance in the macroinvertebrate composition (35% and 13.2%, respectively) (Figure 2). According to the sample scores (axis 2, only), the macroinvertebrate composition varied along the hydrological phases (axis 1, $F_{2,9}$= 0.411, P= 0.675; axis 2, $F_{2,9}$= 8.161, P= 0.010). While Sphaeriidae, Tubificidae and Glossiphoniidae families were more associated with the phase with floods, Hydracarina, Curculionidae and Dytiscidae taxons were more associated with the phase without floods (Figure 2).

Floods of long duration may increase the richness of macroinvertebrates in temporary wetlands (Boulton and Suter, 1986; Davies, 1996). Stenert *et al.* (2003) observed an increase in the macroinvertebrate richness and density after floods of long duration (15-19 days) in a permanent floodplain lake in the South of Brazil. Williams (1997) noticed that the water movement between floodplain systems and the river channel during the flood period facilitated the exchange of macroinvertebrates between both systems. In this study, floods of brief and very brief duration were not able to modify the number of taxons and density of macroinvertebrates. Such a result showed the macroinvertebrate resistance to disturbance by floods of brief and very brief duration. This resistance can be explained by the fact that floods of brief and very brief duration were not able to allow a significant exchange of macroinvertebrates between the floodplain oxbow lake and the river channel. However, surveys focusing the macroinvertebrate exchange between floodplain systems and rivers should be developed.

The frequency of disturbance may influence the macroinvertebrate richness and density. Continuous floods may reduce the invertebrate overall density in seasonal wetlands (Boulton and Jenkins, 1998). Maltchik *et al.* (2005) noticed that the recurrence

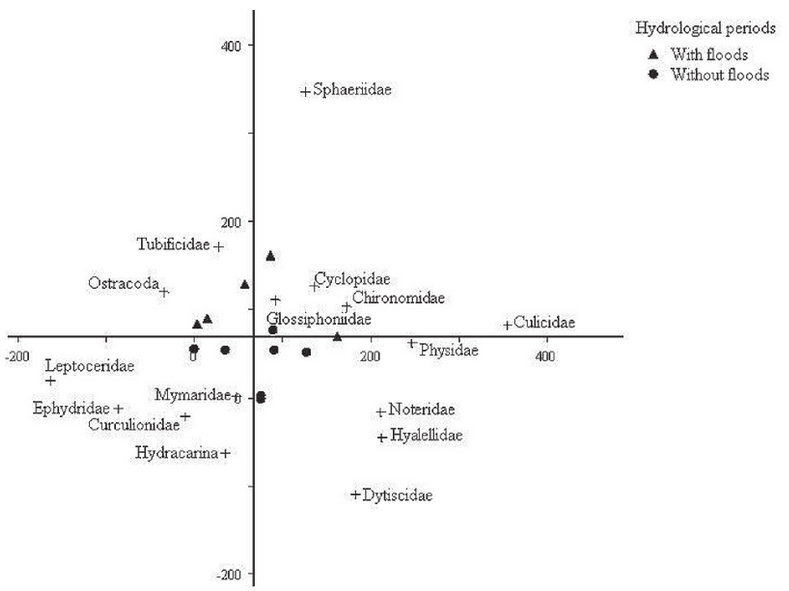

Figure 2. Diagram of Detrended Correspondence Analysis (DCA) ordination: Relationship among collections of each hydrological phase and macroinvertebrate taxons (+).

Table 2. Total richness and density of macroinvertebrate community between dates immediately prior and after floods in an oxbow lake in the South of Brazil during the studied period (2003-2004).

Flood date	Total richness prior to floods	Total richness after floods	Total density prior to floods	Total density after floods
April 25 (1 day)	18	16	127	124
June 16 (1 day)	7	16	76	123
July 07 (3 days)	16	12	123	114
Mean	13.67	14.67	108.67	120.33
Paired *t*-test	t= -0.247, df= 2, P= 0.828		t= -0.657, df= 2, P= 0.579	

Table 3. Resistance (as percent change in density) of the macroinvertebrate families more representative during the studied period in an oxbow lake in the South of Brazil.

	Density change (%)		
Flood date	April 25	June 16	July 07
Flood duration	1	1	3
Dytiscidae	- 100*	**	*
Ephydridae	**	**	- 5.41
Glossiphoniidae	+ 18.75	+ 20	- 50
Tubificidae	+ 350*	- 16.67	+ 2.22

*p < 0.1
**not present

of floods of long duration (3 to 14 days) decreased the macroinvertebrate richness and density in a shallow floodplain lake of South of Brazil. In the studied floodplain oxbow lake, the floods were concentrated on the first three months of the studied period, and the recurrence of the flood events of brief and very brief duration did not decreased the macroinvertebrade resistance to disturbance by floods.

Although the number of taxons and density was similar along both hydrologic phases, the occurrence of flood events triggered a difference in the composition of macroinvertebrates in the studied oxbow lake. Some taxons occurred in only one hydrologic phase. While nine taxons were present on the flood phase only, 16 new taxons showed up in the phase without floods, thus characterizing some composition change between both hydrological phases. Van den Brink and Van der Velde (1991) observed that the macroinvertebrate composition varied between years with and without floods in floodplain waters of the Netherlands. They evidenced that while the water mites and insects (especially Coleoptera and Trichoptera) were more abundant in the years without floods or with infrequent floods, the density of mollusc species was positively related to flood occurrence and frequency. In this study, a mollusc family (Sphaeriidae) was associated with the phase with frequent floods, and the water mites (Hydracarina) and Coleoptera families (Curculionidae and Dytiscidae) were associated with the phase without floods.

The macroinvertebrate community in the studied floodplain oxbow lake was resistant both to floods of brief and very brief duration and to the recurrence of these events, although it was noticed a variation gradient in the composition between the phases with and without floods. But long-lasting studies should be carried out to precisely assess the stability of the macroinvertebrate community in floodplain systems of the Neotropical region.

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